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RESULTS OF TANK TESTING SUBMERGED-ARC WELDING DEPOSITS MADE USING OERLIKON TIBOR 22 WIRE IN COMBINATION WITH VARIOUS FLUXES

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MTL 89-49(TR)

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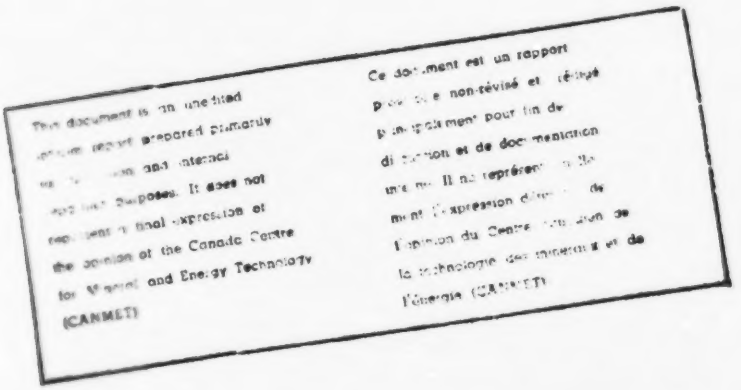
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13 pp

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90-05999/

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RESULTS OF TANK TESTING SUBMERGED-ARC WELDING DEPOSITS MADE USING OERLIKON TIBOR 22 WIRE IN COMBINATION WITH VARIOUS FLUXES

by

R.J. Brigham and V. Mitrovic-Scepanovic

ABSTRACT

Four submerged-arc weldments using TiBor 22 wire with various fluxes were compared with a domestic EM12K/F4803 combination in the CANMET tank test. In general, all of the weld metal/flux combinations provided an excellent match with the 1.2% Mn baseplate in terms of both weld metal and heat-affected zone (HAZ) attack.

LABORATOIRES DE LA TECHNOLOGIE DES METAUX
RAPPORT: MTL 89-49(TR)

RESULTATS DU TEST DE RESERVOIRE SUR DES SOUDURES FABRIQUEES AVEC UN FIL OERLIKON TIBOR 22 EN COMBINAISON AVEC DIVERS FLUXS

par

R. J. Brigham et V. Mitrovic-Scepanovic

RESUME

Quatre soudures fabriquées avec un fil TIBOR 22 en combinaison avec divers fluxs ont été mises en comparaison avec une soudure domestique EM12K/F4803 en utilisant le test de réservoir. En général, toutes les combinations de fils métalliques et de fluxs ont fourni un excellent parti avec la plaque de base contenant 1.2% de Mn en relation avec le métal de soudure et la zone affectée par la chaleur.

INTRODUCTION

Under contract to the Canadian Coast Guard (Fleet Systems), Malik and Chiu (1) prepared five trapezoidal plates containing submerged-arc welds for testing in the CANMET tank test. The welding consumables were as follows:

Weld 065A: TiBor 22 wire - imported basic flux
Weld 065B: TiBor 22 wire - domestic neutral flux
Weld 065C: TiBor 22 wire - domestic basic flux
Weld 065D: TiBor 22 wire - domestic basic flux
Weld 065E: Domestic EM12K wire - F4803 neutral flux combination (CSA W48.6)

The compositions of the weld metals and base plate reproduced from the Materials Technology Centre report (1) are given in Table 1. Microstructural analysis, mechanical properties and corrosion rates determined by anodic dissolution tests were also determined by Malik and Chiu. The anodic dissolution results have been recast in Table 2 to reflect the measurement of the maximum depth of attack from the most corrosion resistant part of the weldment in this case, the weld metal.

EXPERIMENTAL

The five trapezoidal specimens containing weldments were subjected to the standard CANMET tank test (2,3) for 6 months in 3.5% NaCl solution held at approximately 1 to 2°C. The samples were taken out of the tank at two-month intervals; the corrosion products were removed by wire brushing, and the depth of attack of the weld metal and heat-affected zones were measured using a profilometer. In addition, a micrometer was used to confirm the depth of attack at selected points over the whole surface after 6 months of exposure. The maximum depth of attack measured from the original surface was used as a criterion for the degree of corrosion.

RESULTS AND DISCUSSION

Photographs of the corroded samples are shown in Fig. 1 to 5 and the maximum depths of attack of the weld metal and heat-affected zones are listed in Table 2 where they can be compared with the anodic dissolution results.

In general, there is an excellent match between all of the weldments and the baseplate. This is obvious from the photographs of the corroded plates (Fig. 1 to 5) and measurements of the maximum depth of attack in both tank tests and anodic dissolution tests (Table 2). However, there are some subtle differences in the various samples:

065A - The weld metal on the flat part of the specimen where the crown has been removed is completely resistant leading to deep HAZ attack, especially at the last pass. Weldment A is clearly the most resistant of the 5 submerged-arc welds investigated.

065B - This weld metal has 4 pits only on the flat surface. Although the depths have been measured and recorded in Table 2, these numbers do not accurately reflect the degree of overall attack. There is a perfect match between weld metal B and the base plate as indicated by the minimal extent of HAZ attack at both the first and last passes.

065C - This weld metal is slightly more resistant than B. There are a few pits but they are relatively shallow. The extent of HAZ attack is similar to that experienced with A.

065D - This weld metal is the most prone to attack but is still sufficiently resistant to cause some HAZ attack.

065E - There is some general attack in the weld metal with some minor pitting. HAZ attack is minimal at the first pass but more pronounced at the last pass.

On the basis of the above observations, the five weld metal/flux combinations can be rated in terms of corrosion resistance

$$A > C \sim B \sim E > D$$

This rating is consistent with the behaviour of the weld crowns as well (see Fig. 1 to 5).

Because of the pitting morphology, it is difficult to quantify the corrosion in terms of maximum depth of attack. Notwithstanding this limitation, the numbers in Table 2 are in general agreement with the degree of attack observed in Fig. 1 to 5.

The tendency toward enhanced HAZ attack at the last pass relative to the first is common to all of these multipass weldments and is obvious from the pictures if not in Table 2. Low temperature transformation products which are responsible for enhanced corrosion in the HAZ formed by the first pass are tempered and consequently modified by the thermal transients resulting from subsequent passes. No such thermal transient occurs in the case of the last pass to modify the microstructure. It is clear that the low temperature transformation products responsible for enhanced attack are highly unstable since the modest degree of heat treatment associated with subsequent passes is sufficient to cause a significant reduction in HAZ corrosion.

CONCLUSIONS

In general, all of the TiBor 22 wire/flux combinations (A to D) provide an excellent match with a 1.2% Mn steel plate and have been shown (1) to meet the mechanical property requirements. Considering corrosion only, sample E is also a good match but lacks the required toughness.

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3. L.D. Parkinson, L. Malik, V. Mitrovic-Scepanovic and R.J. Brigham, Evaluation of Shielded Metal Arc Welding Consumables for Repair of Weld-Zone Corrosion, Can. Met. Quart.28 135 (1989).

Table 1. Chemical analysis (wt %)

(a) Base material

Base material	C	Mn*	Si	P	S	Cu	Ni	V	Nb	Al
Test material for corrosion samples (350 WT)	0.10	1.20-1.24	0.23	0.012	0.010	0.05	0.07	0.044	0.039	0.051
Extension for mechanical tests (300 W)	0.16	1.10	0.19	0.014	0.012	0.01	0.01	--	--	0.33

* Three separate analyses.

(b) Weld metal

Weld I.D.	C	Mn	Si	P	S	Ti	B	Mo	Cu
A (T)	0.09	1.09	0.21	0.015	0.006	0.01	<0.0002	0.24	0.21
(M)		1.00	0.19			0.018	0.0008		
B (T)	0.08	1.09	0.31	0.016	0.007	0.01	0.0004	0.23	0.22
(M)		1.10	0.30			0.016	0.0008		
C (T)	0.07	1.12	0.27	0.014	0.008	0.01	0.0005	0.22	0.20
(M)		1.20	0.29			0.017	0.0014		
D (T)	0.07	1.17	0.27	0.014	0.006	0.01	0.0006	0.25	0.22
(M)		1.10	0.30			0.020	0.0012		
E (T)	0.06	1.22	0.28	0.015	0.008	0.01	<0.0002	0.01	0.10
(M)		1.20	0.29			0.0039	<0.0005		

(T) - analysis carried out by Technitrol, Montreal.

(M) - analysis carried out by Metals Technology Laboratories, Ottawa.

Table 2. Maximum depth of corrosive attack (μm)

	Anodic dissolution test			Tank test		
Sample	Weld metal	HAZ 1st Pass	HAZ Last Pass	Weld Metal	HAZ 1st Pass	HAZ Last Pass
065A	335	444	408	--	1067	1321
065B	230	213	280*	1524	--	686
065C	185	172	367	991	1143	1397
065D	223	350	249	1651	1041	1016
065E	137	276	271	940	838	1651

* Extension steel - 1.1% Mn

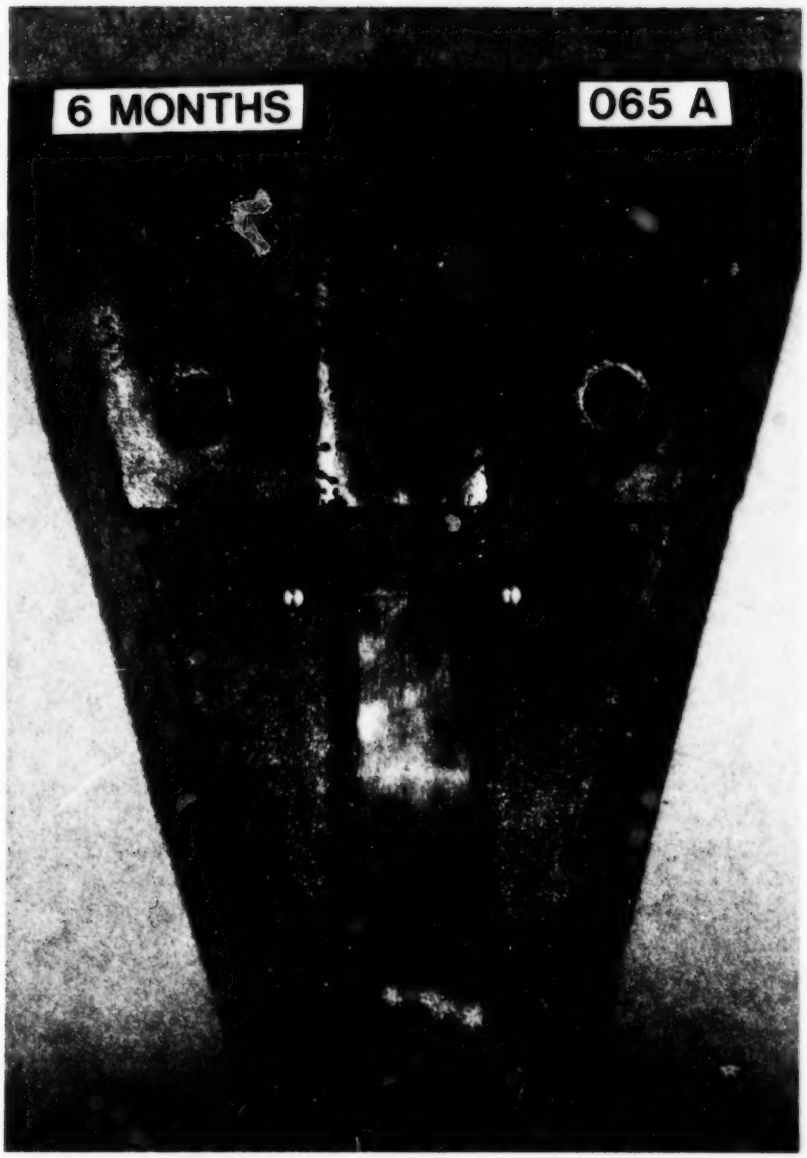

Fig. 1. Photograph of sample 065A after tank testing.

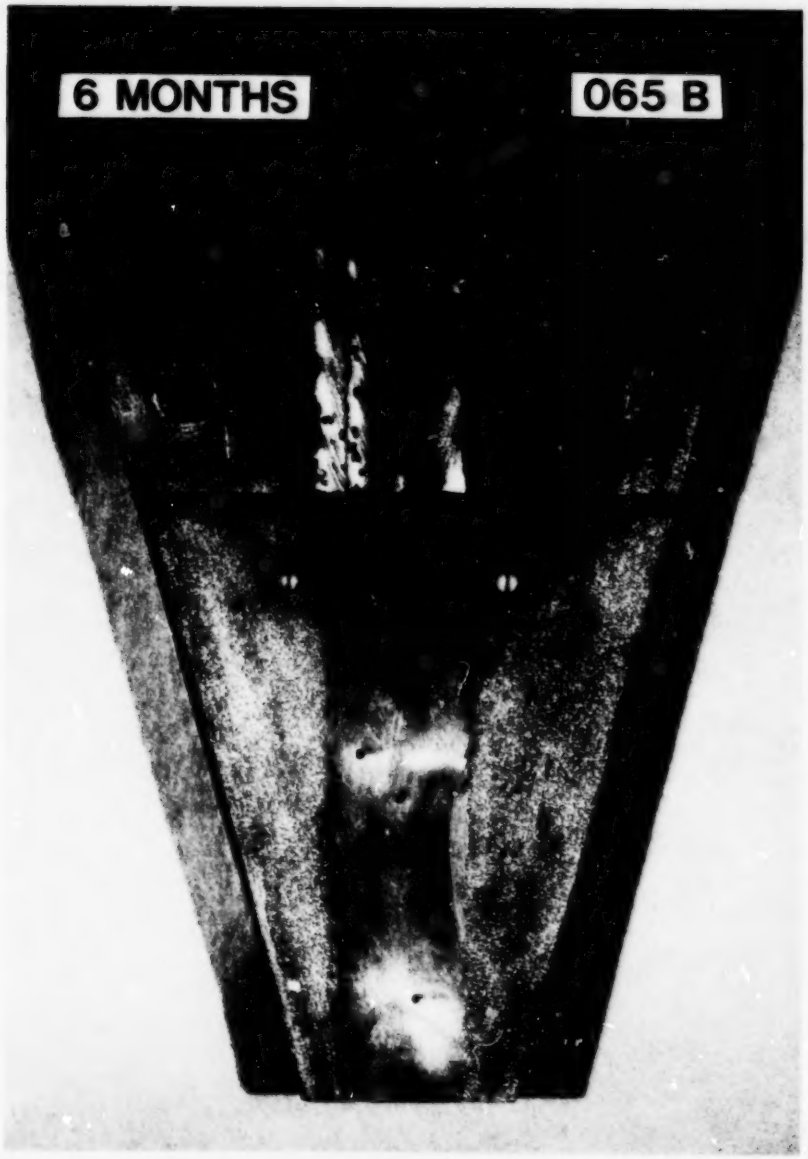

Fig. 2. Photograph of sample 065B after tank testing.

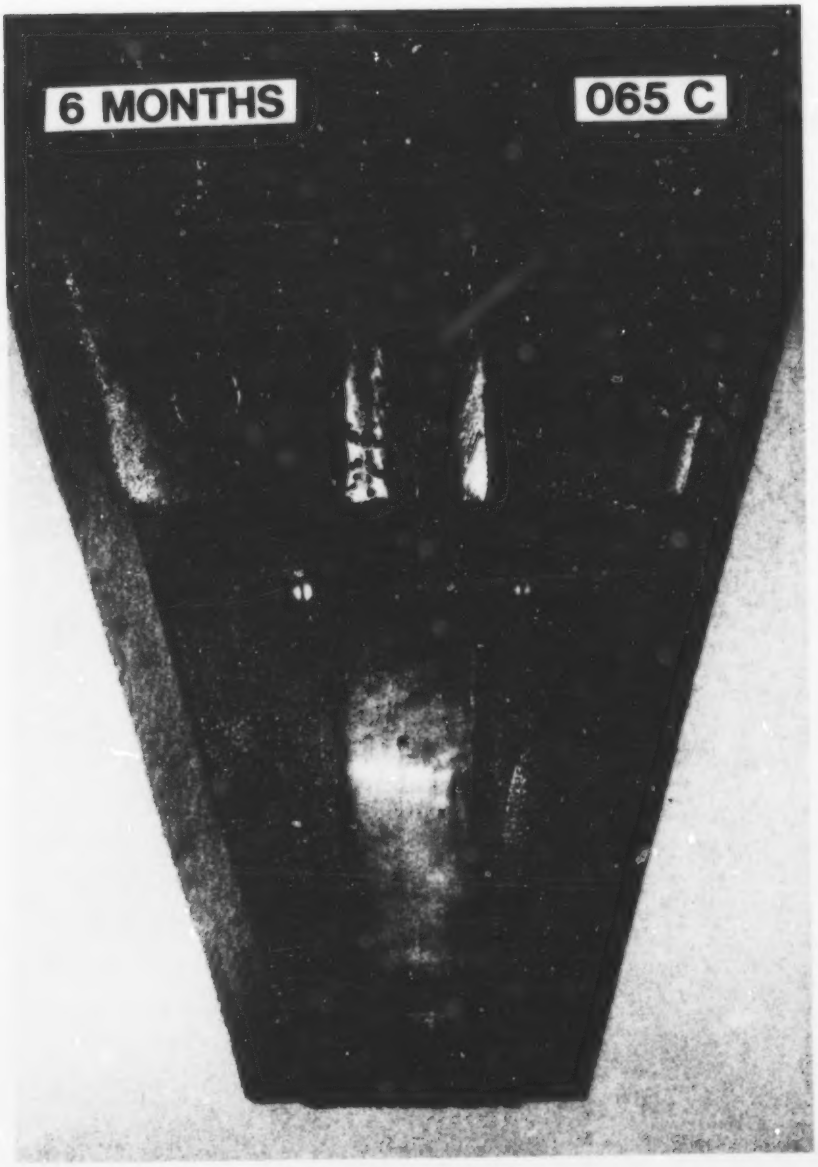

Fig 3. Photograph of sample 065C after tank testing.

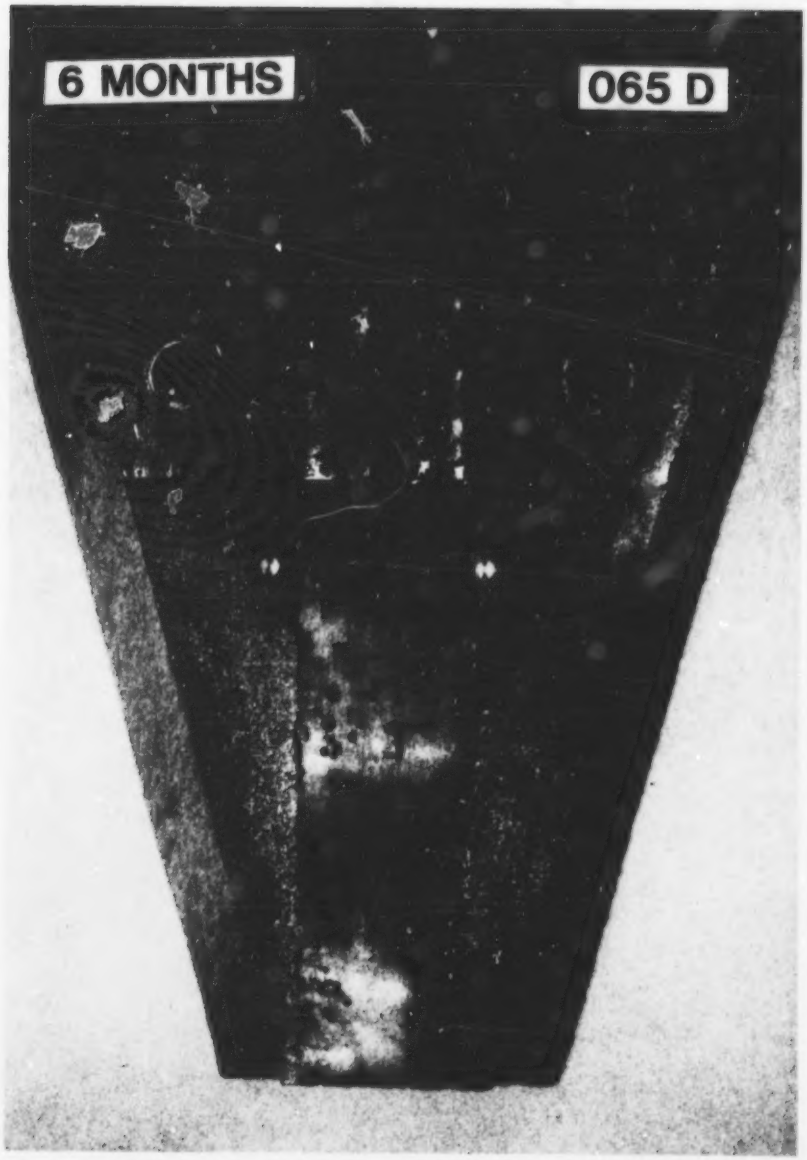

Fig. 4. Photograph of sample 065D after tank testing.

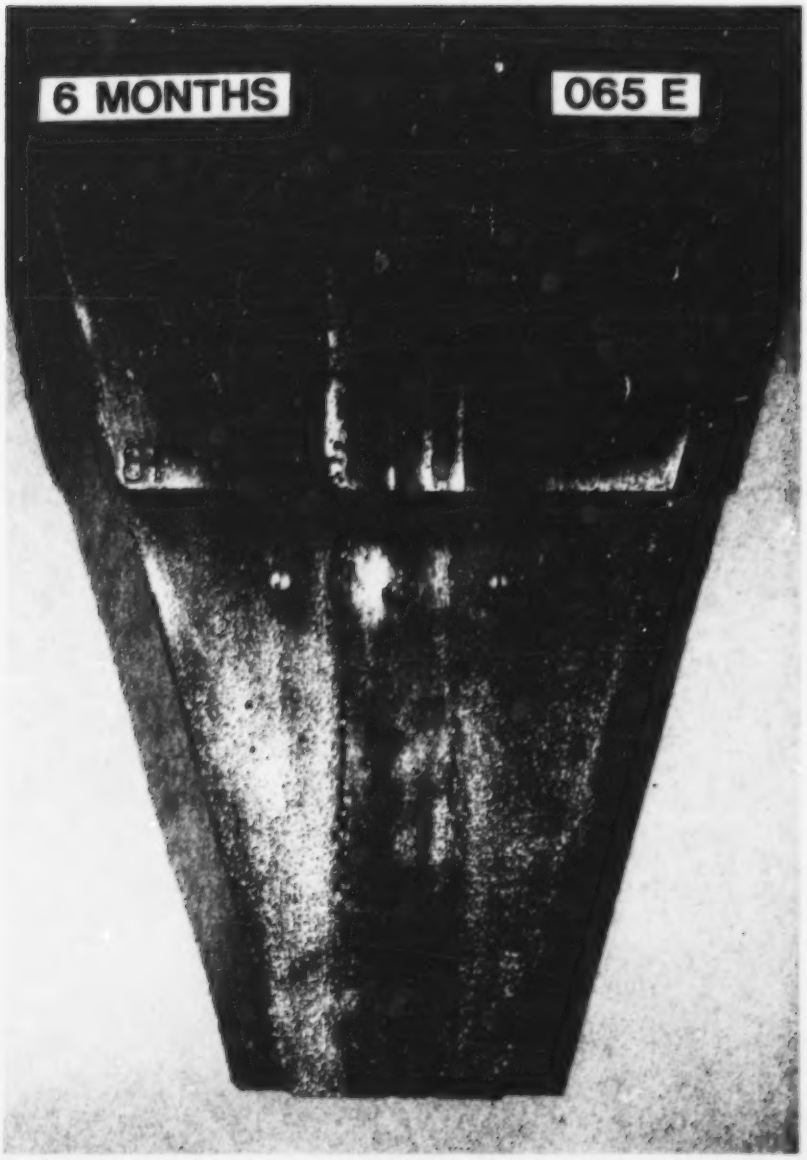

Fig. 5. Photograph of sample 065E after tank testing.